



Pacific Harbor Seal (*Phoca vitulina richardsi*) Monitoring at Point Reyes National Seashore and Golden Gate National Recreation Area

2010 Annual Report

Natural Resource Technical Report NPS/SFAN/NRTR—2011/465



ON THE COVER

Pacific harbor seals (*Phoca vitulina richardsi*), including a red-pelaged seal, hauled out at Double Point, Point Reyes National Seashore.

Photograph by: Sarah Codde

Pacific Harbor Seal (*Phoca vitulina richardsi*)
Monitoring at Point Reyes National Seashore and
Golden Gate National Recreation Area
2010 Annual Report

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Sarah Codde, David Press, Dale Roberts, and Sarah Allen

Harbor Seal Inventory & Monitoring Program
Point Reyes National Seashore
1 Bear Valley Road
Point Reyes Station, CA 94956

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Abstract

Pacific harbor seals (*Phoca vitulina richardsi*) are the dominant and only year-round resident pinniped in the San Francisco Bay Area, California. Long-term monitoring studies have been conducted at the largest harbor seal colonies in Point Reyes National Seashore since the mid 1970's. The objectives of monitoring each site and the population as a whole are to i) detect changes in population size, ii) detect changes in reproductive success by way of pup production, and iii) identify anthropogenic or environmental factors that may affect the condition of the population (Adams et al. 2009).

Harbor seal surveys were conducted throughout the 2010 breeding (March through May) and molting (June through July) seasons once to twice per week at the largest Point Reyes and Golden Gate harbor seal colonies, collectively referred to as Marin County locations. Members of the Harbor Seal Monitoring Volunteer Program helped to complete 214 surveys at eight Marin County locations, contributing an estimated 422 hours. During the breeding season, 2,128 adult and immature seals and 811 seal pups were counted at all Marin County monitoring locations. Drakes Estero had the most adults (610), followed by Double Point (380). Drakes Estero and Double Point accounted for 56% (453) of pups at Marin haulouts. During the molting season, 2,875 animals were counted at Marin County locations. The adult and pup maximum counts during the breeding season and the molting season maximum count were all the lowest recorded in the past ten years. During surveys, 114 disturbances to seals were recorded. The most frequent causes were human on foot (31%), unknown (26%), and motorboats (24%). Thirteen regional surveys were conducted throughout the season at locations in Sonoma, Marin, San Francisco, and San Mateo counties. Of the counties surveyed, Marin County locations accounted for 62% of breeding season adults/immatures, 78% of pups, and 66% of seals during the molting season.

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Introduction

The mission of the National Park Service is “to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (NPS 1916). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1998). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The San Francisco Bay Area Network (SFAN) includes sites such as, Golden Gate National Recreation Area, John Muir National Historic Site, Pinnacles National Monument, and Point Reyes National Seashore. The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Our intent has been to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Pacific harbor seals represent a high priority vital sign for SFAN because they are ecologically significant, have protected status through the Marine Mammal Protection Act, and are of high interest to the public (Adams et al. 2006; Adams et al. 2009).

Harbor seals were also identified as a marine mammal species most likely to benefit from the establishment of marine protected areas (MPAs) in the north central California coast region under the Marine Life Protection Act (CDFG 2009). Five MPAs were selected within Point Reyes National Seashore along with three special closure areas where harbor seals may benefit. The MPAs were implemented in 2010 by the California Department of Fish and Game in cooperation with the National Park Service and monitoring data collected on harbor seals under this program may contribute to the assessment of the efficacy of the MPAs.

The information presented in this report is a summary of the harbor seal data collected at Point Reyes National Seashore and Golden Gate National Recreation Area during the 2010 breeding and molting seasons, March-July. Summary data collected as part of a region-wide survey effort, including adjacent areas (San Francisco Bay, San Mateo County, and Sonoma County) where NPS surveys were conducted in conjunction with other agencies and organizations for 2010, are also presented. This report is not intended to analyze long-term trends in the harbor seal data set, which are more appropriately investigated at five year intervals (i.e. Allen et al. 2004). Furthermore, this document is not intended to report on or analyze data specific to NPS management issues related to harbor seals.

Background

Pacific harbor seals (*Phoca vitulina richardsi*) are the dominant and only year-round resident pinniped in the San Francisco Bay Area, California. The population at Point Reyes National Seashore represents the largest concentration of harbor seals in the State of California, and accounts for approximately 20% of the mainland molting population (Lowry et al. 2005). Much of the Point Reyes coastal zone remains relatively pristine and provides good marine and

terrestrial habitat for seals to rest, molt, feed, and breed where human encroachment is minimal (Figure 1). The inaccessibility of much of the area has historically afforded some protection from human disruption during the seals' terrestrial resting periods; however, some pinniped populations in California are still recovering from a long period of exploitation that did not end until the passage of the Marine Mammal Protection Act in 1972 (Sydeman and Allen 1999). Human disturbance of seals at colonies is of interest to the National Park Service (NPS) because over 2.1 million visitors visit Point Reyes annually (NPS 2009) and several million more visit the Golden Gate National Recreation Area, many of whom visit tidepools, beaches and estuaries within the parks. The parks may implement management actions to reduce disturbance to seals at colonies, if appropriate.

Objectives

Long-term monitoring studies of harbor seals have been conducted intermittently at the largest colonies in Point Reyes National Seashore since the 1970's (Chan 1979, Allen and Huber 1984; Allen et al. 1989; Sydeman and Allen 1999; Allen et al. 2004). The objectives of monitoring each site and the population as a whole are to i) detect changes in population size, ii) detect changes in reproductive success by way of pup production, and iii) identify anthropogenic or environmental factors that may affect the condition of the population. The monitoring objectives and protocol are described in detail in the *San Francisco Bay Area Network Pinniped Monitoring Protocol* (Adams et al. 2009).



Figure 1. Harbor seals resting onshore during the pupping season at Seal Island within Tomales Bay. Photograph by Sue Van Der Wal.

Methods

Study Area

The study area extends from Tomales Point to San Francisco Bay (Figure 2). The Point Reyes peninsula extends from the mouth of Tomales Bay (Lat. 38° 30'N) south to Bolinas Lagoon (Lat. 37° 30'N). Point Bonita is located in the Marin Headlands, at the mouth of San Francisco Bay in the Golden Gate National Recreation Area. For this paper, the Point Reyes sites and Point Bonita are collectively referred to as Marin County locations. Point Reyes National Seashore, Golden Gate National Recreation Area, Gulf of the Farallones National Marine Sanctuary, the California State Parks, and the county parks share jurisdiction over segments of this coastline, but overall, NPS lands account for most of the shoreline.

The topographic diversity of this coastal zone provides a broad range of substrates for harbor seals to come ashore. These include tidal mud flats, offshore and onshore rocky tidal ledges, and sandy beaches. A “haulout site” is defined as a terrestrial location where seals aggregate for periods of rest, birthing, and nursing of young (Harvey 1987; Thompson 1987). Each colony site, or location, is comprised of several “subsites”, or distinct areas of beach, rock outcrops, or sandbars where harbor seals haul out. Coastal embayment sites include Tomales Bay, Drakes Estero, and Bolinas Lagoon. Coastal sites surveyed include Tomales Point, Point Reyes Headlands, Duxbury Reef, Double Point, and Point Bonita (Figure 2).

Sampling Design

The current population size and distribution of the harbor seal breeding population allows surveyors to monitor all breeding sites in Point Reyes National Seashore and the Golden Gate National Recreation Area. Thus, spatial stratification or other sampling techniques were not needed to decide which haul outs to include for monitoring. Survey frequencies and timing capture the date of the first pup, the peak of the breeding and molting seasons, and have been shown to have sufficient ability to detect meaningful population changes over time. The main parameters monitored are reproductive success, population size, distribution, phenology, and disturbances (Adams et al. 2009).

The sampling design for this program enables the data to be integrated with other regional surveys, allowing for the results to be interpreted in a regional context. Annually, the National Park Service participates in regional harbor seal surveys during the breeding and molting seasons, with the Point Reyes National Seashore coordinating the central California coast surveys. Regional survey sites include colonies in Sonoma County (Sea Ranch, South Sonoma sites, Jenner, and Bodega Marine Reserve), San Francisco Bay (Castro Rocks, Alcatraz, Yerba Buena Island, Mowry Slough and Newark Slough), and San Mateo County (Fitzgerald Marine Reserve, Point San Pedro, Cowell Ranch Beach, Pescadero, Pebble Beach, and Bean Hollow) (Figure 2).

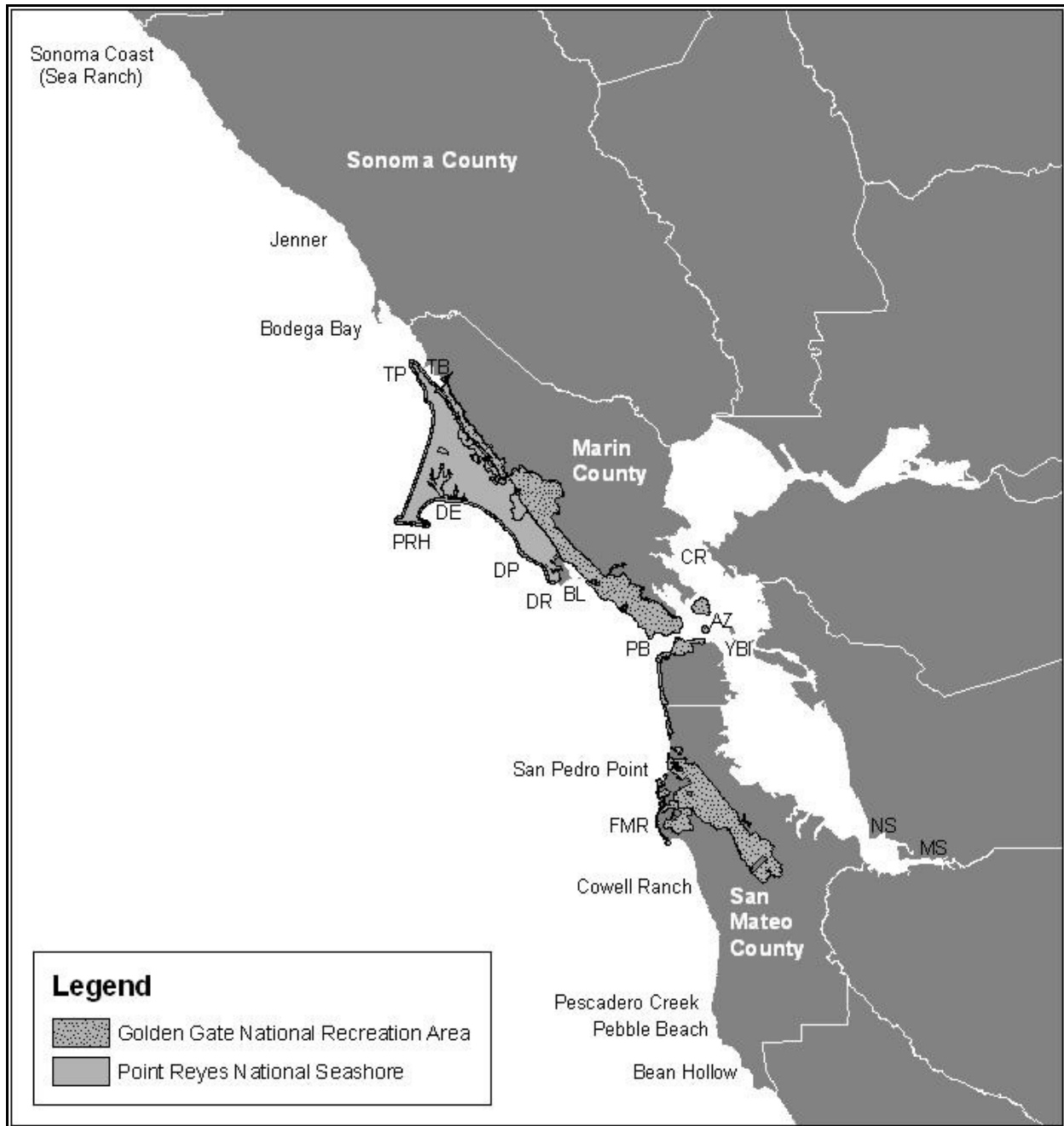


Figure 2. Regional survey sites in San Francisco Bay and Sonoma, Marin, and San Mateo counties, California. Map does not present all of the regional survey locations included in Sonoma and San Mateo counties. TB=Tomales Bay, TP=Tomales Point, DE=Drakes Estero, PRH=Point Reyes Headland, DP=Double Point, DR=Duxbury Reef, BL=Bollinas lagoon, PB=Point Bonita, CR=Castro Rocks, AZ=Alcatraz Island, YBI=Yerba Buena Island, NS=Newark Slough, MS=Mowry Slough, FMR=Fitzgerald Marine Reserve.

Surveys

Volunteer observers were trained to monitor harbor seals at designated sites within Point Reyes and at Point Bonita during two classroom and two field sessions in February and March 2010 (Figure 3). Many of the volunteers had been previously trained and returned to the 2010 season with several years of experience. New volunteers were required to be mentored by returning volunteers at a site before they conducted an unsupervised survey.



Figure 3. Volunteer training at Drakes Estero. NPS Photo.

Harbor seal surveys were conducted throughout the breeding (March 1st through May 31st) and molting (June 1st through July 31st) seasons once to twice per week at each Marin County location. Surveys were conducted at medium to low tides (below 3ft) during the day. Surveys were not conducted in heavy fog because of poor visibility and they were not conducted in the rain because harbor seals haul out in lower numbers in the rain (Jemison and Pendleton 2001).

Generally, volunteers surveyed for approximately 2 hours from fixed observation points with all subsites counted approximately every 30 minutes for a total of four counts each survey. Subsites were counted and recorded separately on pre-formatted datasheets and then added for site totals every half hour. Tomales Point, Bolinas Lagoon, and Duxbury Reef often had only two counts each survey due to hiking/traveling time between subsites.

For each subsite the observer recorded the time, number of adult and immature seals, pups, dead pups, red-pelaged seals, and fresh shark-bitten seals. Red pelage is easily identified and results from the deposition of iron oxide precipitates on the hair shaft; it usually extends from the head down to the shoulder and is of interest due to its rarity outside of the San Francisco Bay Area

(Allen et al. 1993). During the molting season (June-August) all animals were counted as adults or immature seals because of the difficulty in distinguishing large pups from immature seals.

On a separate data form, disturbances and potential disturbances were recorded as they occurred. Disturbances included any events that caused the seals to lift their head (head alert), flush (move towards the water), or flush into water, while potential disturbances were defined as any anthropogenic event within a defined haulout zone that had the potential to flush seals. Observers recorded the time, source, and effect of each disturbance. The information on the effect included the reaction of the seals, the number of seals that reacted, and when and where they re-hauled if they were flushed into the water. In some cases the disturbance was not directly observed, but surveyors recorded the number of animals affected with an unknown disturbance. Disturbances were recorded by fixed categories to assist with summary analyses (Table 1).

Table 1. Categories used to record disturbance sources on field datasheets.

Source	Example
Aircraft	Airplane, Helicopter, Hang glider, Ultralight
Bird	Gull, Raven, Turkey Vulture
Dog	Dog, Dog barking
Human	Clam diggers, Hiker, Horse rider, Oyster Worker, Researcher
Motor-boat	Motorboat, Jet ski
Non Motor-boat	Canoe, Kayak, Sailboat, Wind surfer
Other	Coyote, Other Pinniped, Rock Slide, etc.
Vehicle	Bus, Car, Motorcycle

On alternating weekends, regional surveys were conducted at all sites included in regional counts (see Figure 2). Participants in the region-wide surveys included various organizations and volunteers. Regional counts could be conducted at anytime between Thursday and Monday over the selected regional survey weekends.

All count and disturbance datasheets were entered into a relational Microsoft Access database during the course of the field season. At the end of the season, the database records were error-checked against the paper datasheets for accuracy. The records were further reviewed to ensure that only accurate and complete count data were used for analysis. For example, incomplete counts or counts that may have been hampered by poor weather conditions were noted in the database as poor quality surveys and excluded from analysis.

Data Management and Analysis

Although harbor seal data were collected according to subsites at each monitoring location, subsite data are not reported or analyzed within this report. By summing the subsite counts for each survey time interval, the maximum site total was identified for each survey and used for data summaries and analyses. During the breeding months of March, April, and May, the maximum total site count for each survey includes the adult/immature and pup age categories.

The maximum number of seals counted at a site over the course of the entire season is often used for comparisons between years and sites. Because there is little to no movement of harbor seals between sites during both the pupping and molting seasons, it was assumed that individual animals were not counted at more than one site (Lowry 2001, Nickel 2003). The maximum total

count for each year within the study area was determined by taking the sum of the maximum count at each location. The maximum total count was determined separately for the breeding and molting seasons. Maximum counts at each location may have occurred on separate days (Barlow 2002). When compiling count summaries from the harbor seal data, only records noted as high quality counts were included. During the regional survey weekends, it was not uncommon for a site to be surveyed more than once. In these cases, the survey with the greater seal count was used for any regional summaries. A regional population estimate was derived from a correction factor of 1.65 calculated in California to account for seals in the water during surveys (Lowry et al. 2005)

The total maximum counts of breeding season adults/immatures, pups, and molting season harbor seals were averaged separately across survey years 2000 to 2010 and compared to the 2010 data. Inclusion of all survey years in the average calculation accounts for the inherent inter-annual variability in the harbor seal population and in reproductive output.

When examining disturbance events, only actual disturbances, those that elicited a head-alert or flush reaction from the seals, were used for summary analysis. Disturbance tallies were based on disturbance sources rather than the number of subsites or seals affected. Disturbance rates were calculated as the number of disturbance events that occurred during the time period from the first observation to the end of the final observation period. Because the disturbance data were not analyzed for effects on the seal count data in this report, all actual disturbance data were used for analysis regardless of the quality of the associated seal count data. Potential disturbances (events that could potentially elicit a reaction from seals) were recorded by volunteers to quantify any given type of disturbance recurring at a particular site, but this information is not analyzed in this report. These data may be used to understand potential emerging disturbance issues at each location.

The harbor seal monitoring data are dynamic and may change over time as errors are discovered and fixed, and as data analysis procedures are corrected or improved. For this reason, summary data reported here for 2000 to 2009 may differ from data summaries published in previous harbor seal reports. In particular, a thorough review and update to the disturbance data occurred since the 2007 annual harbor seal monitoring report (Truchinski et al. 2008).

Results

Overall

In 2010, 46 volunteers helped to complete 214 surveys at Marin County locations between March 1st and July 31st, completing an estimated 422 hours of monitoring. Each location was surveyed between 8 and 35 times, which includes 13 regional surveys. The low survey count at Point Reyes Headlands resulted from several canceled surveys due to heavy fog. At Marin locations, a maximum of 2,128 adults and 811 pups were observed during the breeding season (March-May) and 2,875 individuals were recorded during the molting season (June-July) (Table 2).

Table 2. Summary data of harbor seal colonies for the 2010 season. All reported numbers reflect the maximum number seen during a single census.

Location	Max # adults in breeding season ¹	Max # pups in breeding season	Max # seals in molting season ²	# Surveys	Max # reds ³	Max # shark bites ³	Max # dead pups ³
Bolinas Lagoon	325	150	404	Weekday: 21 Weekend: 11	13	2	3
Double Point	380	230	737	Weekday: 13 Weekend: 10	9	2	11
Drakes Estero	610	223	718	Weekday: 22 Weekend: 10	11	2	6
Duxbury Reef	33	3	38	Weekday: 21 Weekend: 13	0	1	0
Point Reyes Headlands	67	36	258	Weekday: 8 Weekend: 0	0	0	0
Tomales Bay	330	55	257	Weekday: 14 Weekend: 11	8	1	0
Tomales Point	283	103	319	Weekday: 15 Weekend: 10	4	1	1
Point Bonita	100	11	144	Weekday: 15 Weekend: 20	4	1	0
TOTAL	2,128	811	2,875	214	49	10	21

¹ Adults and immatures during the breeding season, March 1 to May 31.

² All age classes during the molting season, June 1 to July 31.

³ The maximum number observed March 1 to July 31.

Adult and Pup Counts During the Breeding Season

Adults: The maximum count of adult and immature seals during the 2010 breeding season was 2,128 (Figure 4). This is the lowest recorded count in the past ten years. Drakes Estero had the most adults (610), followed by Double Point (380; Table 2).

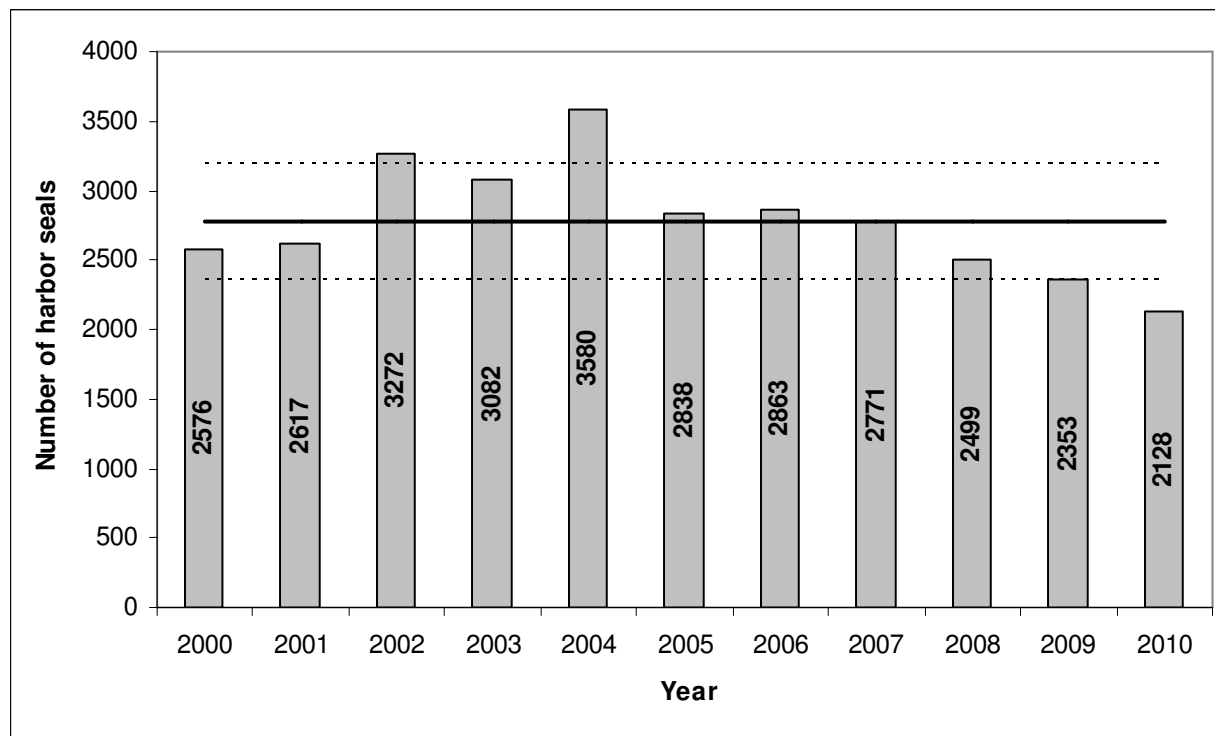


Figure 4. Maximum counts of harbor seal adults and immatures during the breeding season (March-May) for 2000-2010 at Marin County locations. The solid line on the graph represents the mean of the maximum adult counts from 2000-2010 (mean = 2,779.9) and the dashed lines represent one standard deviation from the mean (SD = 416.9).

Pups: The combined maximum pup count for all Marin County locations during the 2010 breeding season was 811 pups (Figure 5). This is the lowest recorded count in the past ten years. Drakes Estero and Double Point accounted for 56% (453) of pups at Marin haulouts, which was consistent with the proportions of pups in the past.

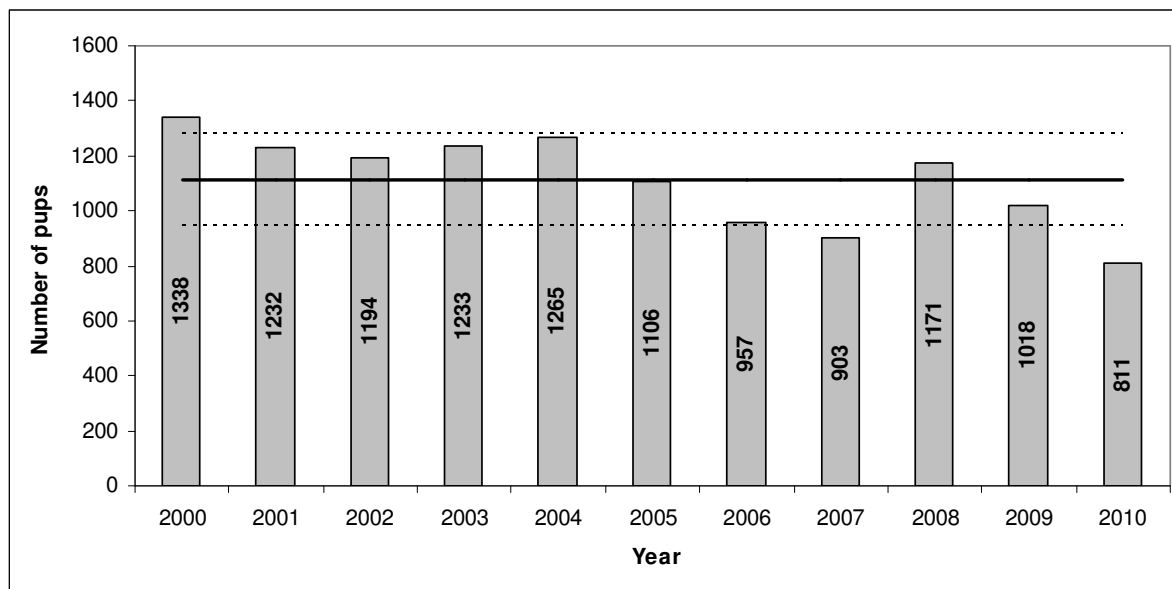


Figure 5. Maximum harbor seal pup counts for 2000-2010 at Marin County locations. The solid line on the graph represents the mean of the maximum pup counts from 2000-2010 (mean = 1,111.6), and the dashed lines represent one standard deviation from the mean (SD = 167.6).

The date of the first pup observed has been documented since 2000, and there is no apparent trend in the date or location of the first pup observed from 2000 to 2010 (Table 3). Two dead pups were seen in early 2010 at Drakes Estero, one in January and one in February. A third dead pup was seen at Tomales Point in late February. On March 9, a lone pup with lanugo coat was seen alive but a far distance from other seals and was not seen again. The first reported viable pup of 2010 was seen on March 18 at Tomales Bay. However, five pups were seen at Double Point two days later and it is not known when these pups were born.

Table 3. Date of first pup observed in the season by location, 2000-2010.

Year	Date	Location
2000	March 14	Point Reyes Headlands
2001	March 16	Tomales Bay
2002	March 3	Drakes Estero
2003	March 27	Bolinas Lagoon
2004	March 20	Double Point
2005	March 6	Drakes Estero
2006	March 9	Double Point
2007	March 2	Double Point
2008	March 16	Bolinas Lagoon
2009	March 6	Tomales Bay
2010	March 18	Tomales Bay

All of the dominant pupping sites (Double Point, Drakes Estero, Tomales Bay, and Tomales Point) decreased in maximum pup numbers from 2009 to 2010, except for Bolinas Lagoon (Figure 6). Tomales Bay experienced the largest one year difference (-38%), followed by Double Point (-23%), and Tomales Point (-20%). Bolinas Lagoon had a small increase of 5%. The

majority of the pupping sites have been showing an overall decline over the past few years, however, Point Bonita, which is not a dominant pupping site, has been increasing (Figure 7).

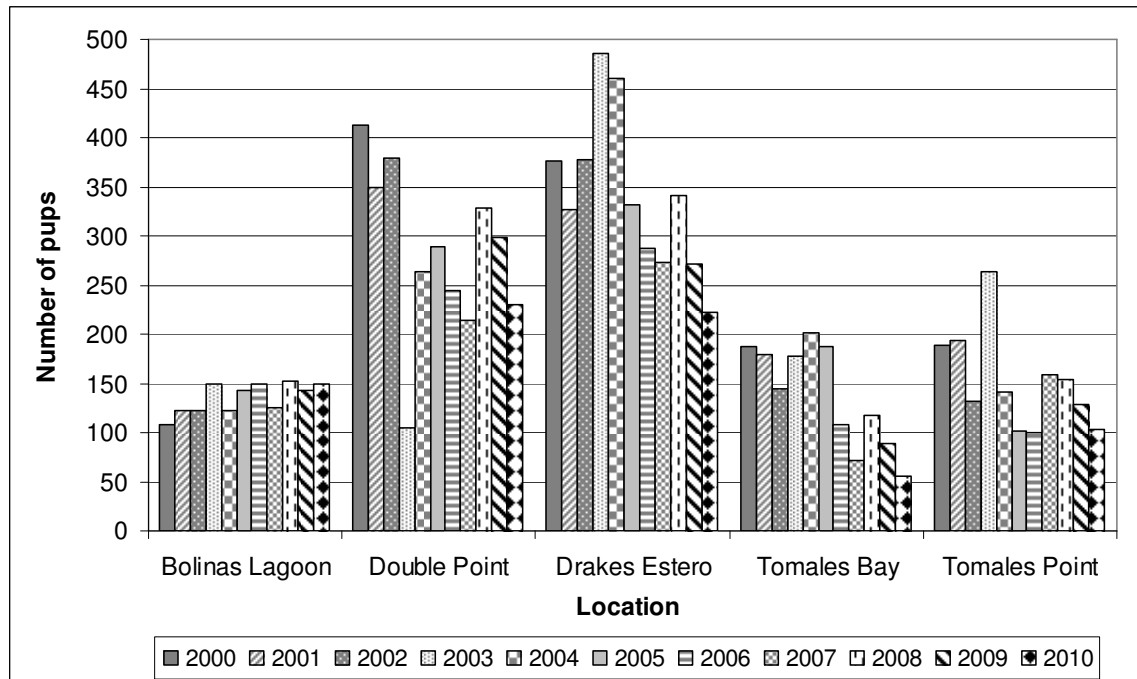


Figure 6. Maximum harbor seal pup counts at the dominant Marin County pupping locations, 2000-2010. The maximums of each site may have been observed on different days.

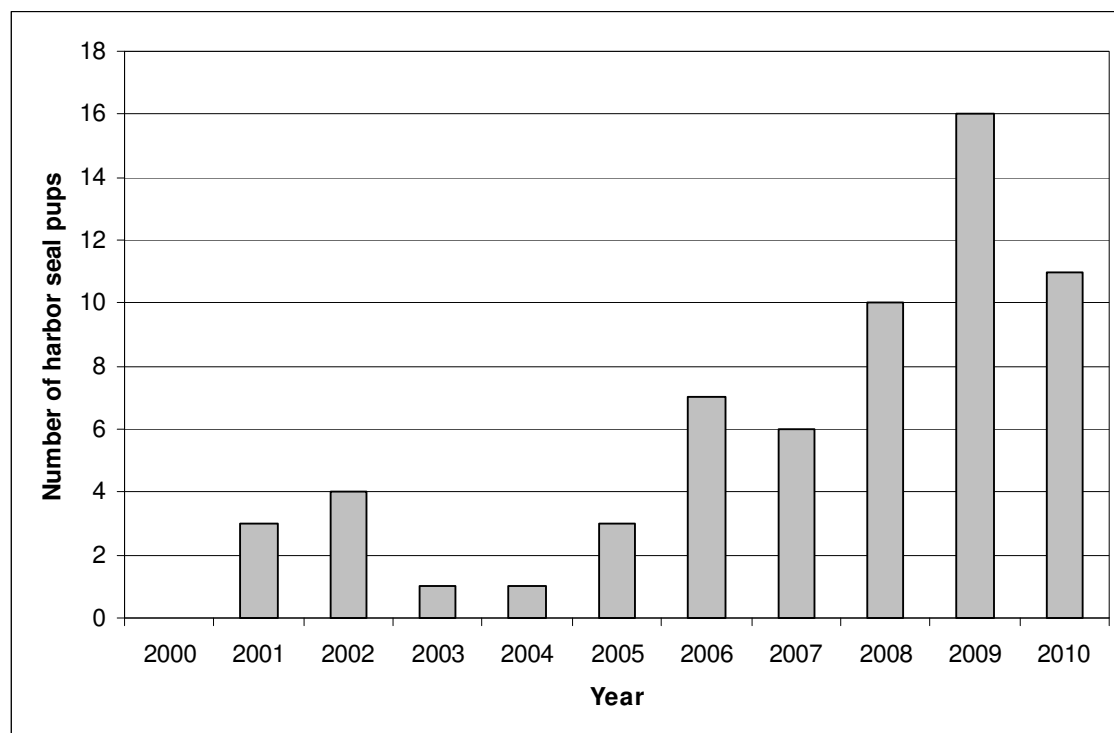


Figure 7. Maximum harbor seal pup counts at Point Bonita, 2000-2010.

Molt Counts

The maximum count of all seals during the 2010 molt season for all Marin County locations was 2,875 seals (Figure 8). This is the lowest recorded count in the past ten years. Drakes Estero and Double Point comprised 51% (1,455) of the total seals counted during the molt season (Table 2). This proportion is an increase from 2009, but consistent with the remaining study years (Codde et al. 2010).

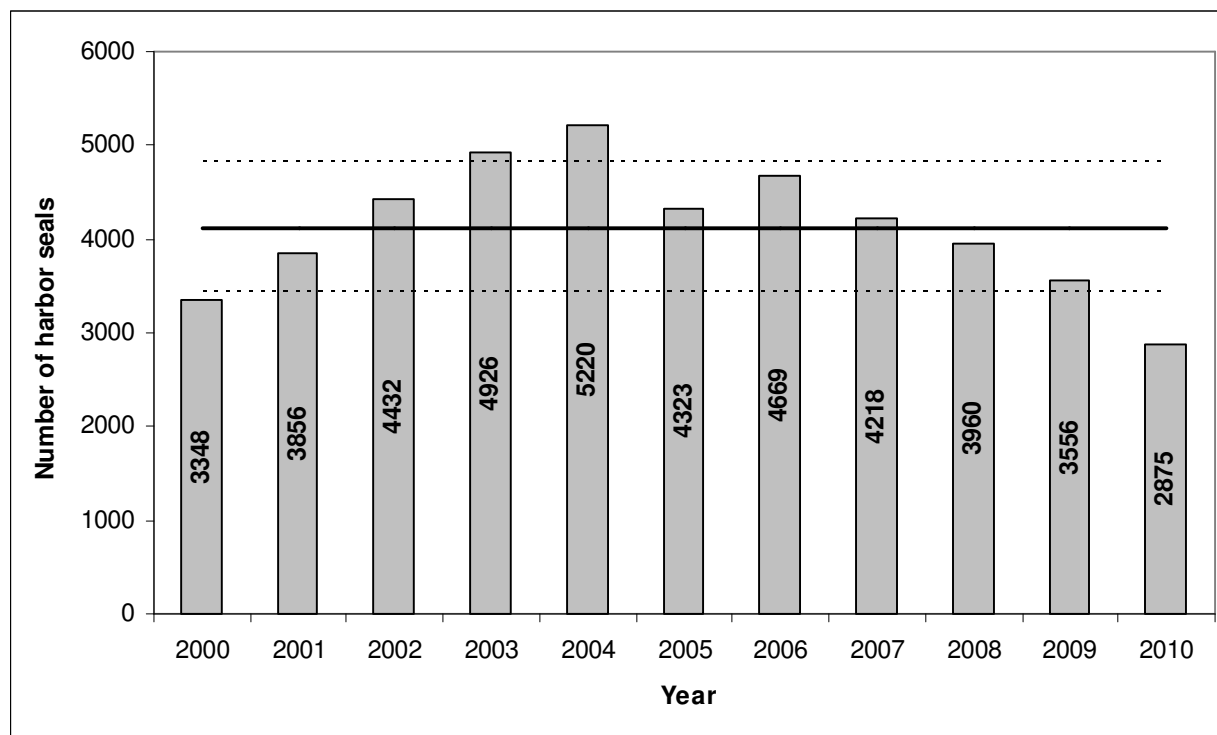


Figure 8. Maximum harbor seal counts during the molt season (June-July) for 2000-2010 at Marin County locations. The solid line on the graph represents the mean of the maximum molt counts from 2000-2010 (mean = 4,125.7) and the dashed lines represent one standard deviation from the mean (SD = 697.7).

Disturbances

At the Marin County locations in 2010, 114 disturbances were recorded that elicited a response from harbor seals (Table 4). The most common disturbance source was humans on foot (31%, Table 4). Unknown and motorboats were the next most common sources with 26% and 24%, respectively. Tomales Bay had the highest number of disturbances with 38, followed by Drakes Estero reporting 30 disturbances. The disturbances at Tomales Bay were mostly related to passing boat traffic, whereas those at Drakes Estero were primarily caused by hikers. Duxbury Reef and Point Reyes Headlands had no disturbances likely because of the remoteness and inaccessibility of these sites.

Table 4. Identified sources of disturbances (head alert, flush, flush into water) for Marin County locations, from March 1st to July 31st, 2000-2010.

	Aircraft		Bird		Dog		Human		Motorboat		Non-Motor Boat		Vehicle		Unknown		Other		Total
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
2000	14	11.3	19	15.3	0	0.0	23	18.5	14	11.3	9	7.3	0	0.0	43	34.7	2	1.6	124
2001	4	3.1	9	6.9	1	0.8	45	34.6	14	10.8	12	9.2	2	1.5	28	21.5	15	11.5	130
2002	9	5.7	11	7.0	0	0.0	48	30.6	19	12.1	15	9.6	9	5.7	39	24.8	7	4.5	157
2003	10	7.5	10	7.5	0	0.0	38	28.6	13	9.8	20	15.0	3	2.3	32	24.1	7	5.3	133
2004	2	2.2	7	7.5	1	1.1	35	37.6	2	2.2	9	9.7	7	7.5	23	24.7	7	7.5	93
2005	10	8.1	10	8.1	2	1.6	43	35.0	9	7.3	14	11.4	1	0.8	31	25.2	3	2.4	123
2006	8	5.1	13	8.3	1	0.6	57	36.3	14	8.9	16	10.2	5	3.2	35	22.3	8	5.1	157
2007	14	6.7	13	6.2	2	1.0	70	33.3	29	13.8	21	10.0	14	6.7	45	21.4	2	1.0	210
2008	4	3.7	5	4.6	0	0.0	51	47.2	11	10.2	10	9.3	5	4.6	18	16.7	4	3.7	108
2009	3	3.1	6	6.3	0	0.0	21	21.9	22	22.9	11	11.5	2	2.1	27	28.1	4	4.2	96
2010	5	4.4	5	4.4	6	1.8	35	30.7	27	23.7	5	4.4	3	2.6	30	26.3	2	1.8	114
Average	7.8	5.6	10.3	7.8	0.7	0.5	43.1	32.4	14.7	10.9	13.7	10.3	4.8	3.4	32.1	24.4	5.9	4.7	133

In 2010, Tomales Bay had the greatest disturbance rate (0.73 disturbances/hr), followed by Bolinas Lagoon (0.39 disturbances/hr) and Drakes Estero (0.38 disturbances/hr; Figure 9). Of the sites that regularly have more than five disturbances per season, Double Point experienced the greatest change compared with 2009 with a 114% increase in the disturbance rate (Figure 10). The number of disturbances at Double Point nearly doubled from 7 disturbances in 2009 to 13 in 2010, but 13 disturbances at Double Point is actually more consistent with other monitoring years. Increases in disturbance rates were also seen at Bolinas Lagoon (44%), Drakes Estero (13%), and Tomales Bay (5%). Tomales Point saw a decrease with -34%. Point Bonita did not experience a change in disturbance rate from 2009. The rates of disturbances vary greatly from year to year depending on activities at each location.

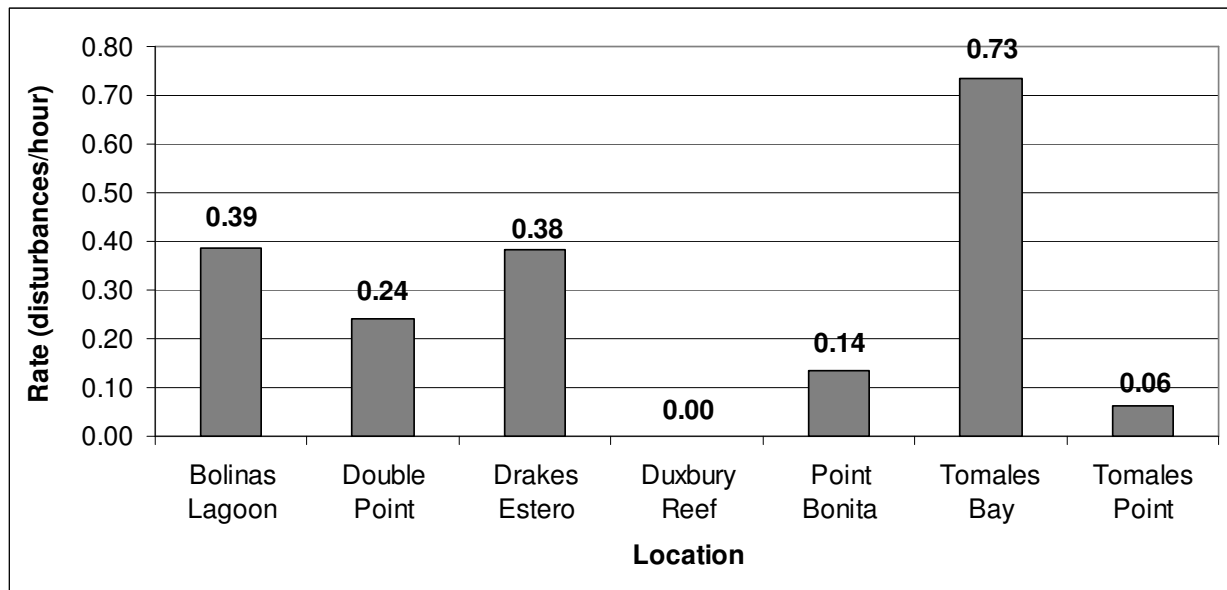


Figure 9. Rates of disturbances per hour at Marin County locations from March through July 2010. Only actual disturbances (head alert, flush, flush water) were used and survey time was based on observation time for all complete surveys (with or without disturbances).

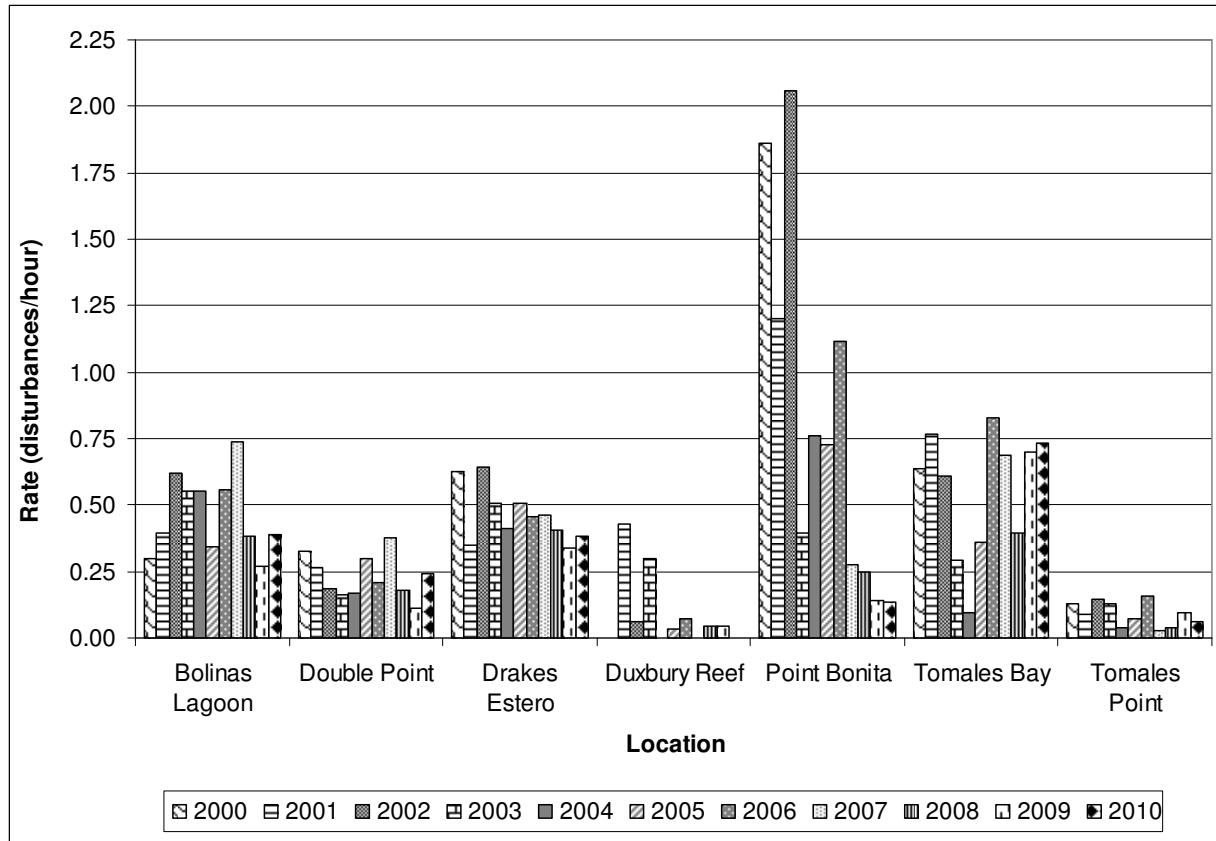


Figure 10. Rates of disturbances per hour at Marin County locations from March through July of 2000-2010. Only actual disturbances (head alert, flush, flush water) were used, and survey time was based on observation time for all complete surveys (with or without disturbances).

Summary by Site

Bolinas Lagoon

Bolinas Lagoon had 32 complete surveys between March 1st and July 31st, 2010. Of those surveys, 21 were on weekdays and 11 were on weekends. The maximum count during the breeding season had 325 adults and 150 pups. The first viable pups were recorded on April 1st, when 11 pups were seen. During the molting season, the maximum count was 404 seals (Table 2). Bolinas had an increase in the number of disturbances as compared to 2009; however, it is still low compared to other years. The primary cause of disturbances was humans, which included visitors and fishermen. This year there was a decrease in disturbances caused by kayaks, but an increase in disturbances caused by humans on foot. This site is along scenic Highway 1 and many people stop to visit the area. The 2010 disturbance rate for Bolinas Lagoon increased from 2009 (0.27 to 0.39 disturbances/hr; Figure 10).

Double Point

Double Point had 23 complete surveys between March 1st and July 31st, 2010. Of those, 13 were on weekdays and 10 were on weekends. The maximum count during the breeding season was 380 adults and 230 pups. Five pups were recorded as the first viable pups at this site on March 20th. The molting season yielded a maximum count of 737 seals (Table 2). Double Point

experienced disturbances which were primarily caused by unknown sources, but also a few caused by birds, humans, and an airplane. The unknown disturbances may be caused by small rockslides from the eroding cliffs above the beaches that observers can't see or hear. During one survey, surfers were observed walking through the colony and caused all 300 seals on the beach to flush into the water. Double Point had an increase in the disturbance rate from last year (0.11 to 0.24 disturbances/hr; Figure 10).

Drakes Estero

The Drakes Estero complex which includes the Limantour Spit had 32 complete surveys between March 1st and July 31st, 2010. Of those, 22 were on weekdays and 10 were on weekends. The maximum count during the breeding season was 610 adults and 223 pups and the maximum molt count was 718 (Table 2). Two lone pups were seen on March 19th, but not seen the next day. Therefore, it is assumed the five pups recorded on March 24th were the first viable pups at this site. Drakes Estero had a high number of disturbances and experienced a small increase in disturbance rate as compared to 2009 (0.34 to 0.38 disturbances/hr; Figure 10). The majority of disturbances were caused by hikers on Limantour Beach due to its easy accessibility. The Estero is seasonally closed to kayaking from March to June during the critical pupping period and no kayaks were reported during this time.

Duxbury Reef

Duxbury Reef had 34 complete surveys between March 1st and July 31st, 2010. Of those, 21 were on weekdays and 13 were on weekends. During the breeding season, the maximum adult count was 33 and the maximum pup count was 3, while during the molting season the maximum seal count was 38 (Table 2). The first day a pup was recorded at this site was on April 15th. Duxbury had the lowest number of seals and no disturbances were recorded there. Disturbances are rarely recorded at Duxbury Reef, possibly due to the poor accessibility of the location.

Point Bonita

Point Bonita had 35 complete surveys between March 1st and July 31st, 2010. Of those, 15 were on weekdays and 20 were on weekends. During the breeding season, the maximum count was 100 adults and 11 pups and the maximum molt count was 144 (Table 2). The first viable pup was seen on April 7th. The maximum pup count has been increasing over the past few years. The disturbances at Point Bonita were caused by various sources, which included motorboats, kayaks, humans on foot, and unknown causes. One disturbance was caused by a class conducting an intertidal study near the harbor seal haulout. There has been a decrease in disturbances caused by humans since the area below the paved walkway was closed to visitors in mid-June 2007. Point Bonita had no change in disturbance rate from last year (0.14 to 0.14 disturbances/hr; Figure 10).

Point Reyes Headlands

Point Reyes Headlands had 8 complete surveys between March 1st and July 31st, 2010. All of the surveys were completed during weekdays. During the breeding season, the maximum adult count was 67 and the maximum pup count was 36, while during the molting season the maximum seal count was 258 (Table 2). The date of the first viable pups is not reliable because of the low amount of surveys completed at this site. There were no recorded disturbances at the Point Reyes Headlands. This site rarely has disturbances because of its remoteness and inaccessibility. Most of the harbor seals were seen at a large elephant seal colony pocket beach. Only two surveys

were completed during the molting season, none of which coincided with the scheduled regional surveys, due to heavy fog that was consistently present in the Point Reyes Headlands.

Tomales Bay

Tomales Bay had 25 complete surveys between March 1st and July 31st, 2010. Of those, 14 were weekday and 11 were weekend surveys. During the breeding season, the maximum adult count was 330 and the maximum pup count was 55, while during the molting season the maximum seal count was 257 (Table 2). The first viable pup at this site and for all Marin County locations was recorded on March 18th. The majority of the disturbances were caused by motorboats traveling around the sandbars. The sandbars in Tomales Bay are a very popular spot for recreational clamming and there were often people on the sandbars during surveys, although, they were only reported to have caused three disturbances in 2010. Tomales Bay had the highest number of disturbances and disturbance rates of all locations in 2010 (0.73; Figure 9). There was only a small increase in the disturbance rate from 2009 (0.70 to 0.73; Figure 10).

Tomales Point

Tomales Point had 25 complete surveys between March 1st and July 31st, 2010. Of those, 15 were on weekdays and 10 were on weekends. During the breeding season, the maximum adult count was 283 and the maximum pup count was 103, while during the molting season the maximum seal count was 319 (Table 2). The first viable pup recorded at this site was on April 3rd. Tomales Point experienced a small number of disturbances, the majority being caused by unknown sources. Due to its remoteness, however, the Tomales Point location is generally not frequented by park visitors. Abalone divers are generally the only people seen near the seal haulouts. However, due to the distance between Tomales Point subsites, observers cannot stay in one location long enough to see if the divers cause any disturbances. During one survey, seals were seen at a haulout site by the observer on their outgoing survey, but were no longer present on the return survey and people were in the vicinity. On two other occasions divers were seen in areas where seals normally haul out, however, no seals were present at the time.

Regional Sites

Thirteen regional surveys occurred between March 1st and August 2nd, 2010 at 22 different locations. Not all sites were surveyed on all scheduled days due to weather conditions or scheduling conflicts. Bodega Marine Reserve was added to the survey locations this year. This site has been included in the regional surveys intermittently in the past, depending on interest from students at the Bodega Marine Laboratory. During the breeding season, a maximum of 3,226 adults and 1,022 pups were observed, although the maximum counts may have occurred on different days for each location (Table 5). During the molting season, the combined maximum count of all seals from each site was 3,920. Marin County locations accounted for 62% of the maximum adult/immature breeding count, 78% of the maximum pup count, and 66% of the maximum molt count. A population estimate for the regional population of harbor seals for the molt season was 6,468 based on a correction factor of 1.65 (1.65×3920) (Lowry et al. 2005). All counties experienced a drop in numbers from 2009 to 2010 for both breeding and molting seasons, except for Sonoma County during the breeding season and San Mateo County during the molting season, which both stayed fairly steady (Figures 11 and 12).

Table 5. Regional surveys of harbor seal numbers in central California, March 1st through August 2nd, 2010. Thirteen surveys were scheduled on alternating weekends, eight during the breeding season and five during the molt. Values reported as average (Avg), standard error (SE), and maximum (Max). ND=No data.

Location	Breeding Season					Molting Season			
	N	Avg adults	SE	Max adults ¹	Max pups ²	N	Avg	SE	Max seals
Sonoma County									
Sonoma Coast	8	113.8	11.0	155	45	5	149.6	15.4	200
Jenner	8	82.0	19.3	170	21	5	174.0	17.7	224
Bodega Marine Reserve	7	29.4	6.8	49	5	5	47.6	7.8	68
Marin County									
Tomaes Bay	7	269.0	16.1	330	55	3	191.7	28.1	243
Tomaes Point	7	207.0	16.5	272	81	5	284.6	14.5	319
Point Reyes Headland ³	3	50.0	11.5	67	36	0	ND	ND	ND
Drakes Estero ³	8	375.8	41.3	481	224	5	501.8	83.0	718
Double Point ³	8	340.9	36.7	380	240	4	452.5	105.5	737
Duxbury Reef	8	13.8	3.9	33	3	5	19.2	5.6	38
Bolinas Lagoon	8	169.5	33.2	324	151	5	311.2	37.6	404
Point Bonita	8	47.3	12.7	100	11	5	124.8	9.8	144
San Francisco Bay									
Alcatraz	7	3.6	1.3	10	0	5	2.2	1.1	6
Castro Rocks	8	125.6	7.1	165	38	5	91.8	9.6	116
YBI	8	92.6	9.9	132	5	4	61.0	13.2	89
Newark Slough	3	24.0	6.7	37	15	4	9.8	3.9	19
Mowry Slough ³	4	61.0	21.2	119	30	4	34.5	11.3	54
San Mateo County									
Point San Pedro	6	5.3	1.9	12	2	1	ND	ND	23
Cowell Ranch	6	71.5	13.3	110	16	4	59.8	13.9	91
Pescadero	7	22.9	5.2	41	6	5	30.4	6.1	51
Pebble Beach	7	36.9	7.2	52	4	5	63.2	8.9	91
Bean Hollow	7	0.0	0.0	0	0	5	0.0	0.0	0
Fitzgerald Marine Reserve ³	8	141.9	14.2	187	34	5	219.4	19.6	285
ALL SITES				3,226	1,022	3,920			

¹Based on the total for a single day.

²Based on the total for the same single day as above

³Includes surveys that occurred outside of regional weekend period

Complete data sets for the regional surveys outside of Point Reyes are only available since 2005 and, therefore, comparisons can only be made during the years between 2005 and 2010. Maximum counts from Bodega Marine Lab were not included in the multi-year comparisons since the site was not surveyed in recent years. Overall, during the breeding season, all counties except Marin stayed fairly steady in the annual number of adults and immatures recorded since 2005 (Figure 11). During the molting season, all counties showed variability in annual harbor seal numbers since 2005 (Figure 12). Further analysis is needed to determine if this is significant. Note that Figure 12 includes all age classes since it is difficult to identify pups during this time.

Within the San Francisco Bay, high counts for seals occurred at Castro Rocks, Yerba Buena Island, and Mowry Slough. The most pups were recorded at Castro Rocks and Mowry Slough. In San Mateo County, the highest concentration of seals was on the coast at Fitzgerald Marine Reserve, followed by Cowell Ranch. In Sonoma County, Jenner had the high count of adult seals, followed closely by the Sonoma Coast location. The high pup count was recorded at the Sonoma Coast and, therefore, the combined maximum counts of adults and pups resulted in this site having the higher seal count over Jenner.

The majority of the disturbances in San Francisco Bay were recorded at Castro Rocks and Yerba Buena Island. However, the documented disturbances at Castro Rocks always resulted in the seals flushing into the water; whereas, the seals at Yerba Buena Island always reacted to the disturbances with only a head alert. The disturbance sources at Castro Rocks consisted of researchers, kayaks, bridge maintenance, and unknown sources. The sources at Yerba Buena Island were a motorboat, USCG aircraft, and bridge traffic. Alcatraz had minimal disturbances and both Mowry and Newark Sloughs had no recorded disturbances. In San Mateo County, only Fitzgerald Marine Reserve experienced a disturbance, which was caused by people yelling. At Pebble Beach it was noted that on one occasion there were fishermen near a known haulout site, but no seals were present. In Sonoma County, only Jenner had documented disturbances. The sources included tourists and an aircraft. Three disturbances resulted in head alerts and only one caused the seals to flush into the water.

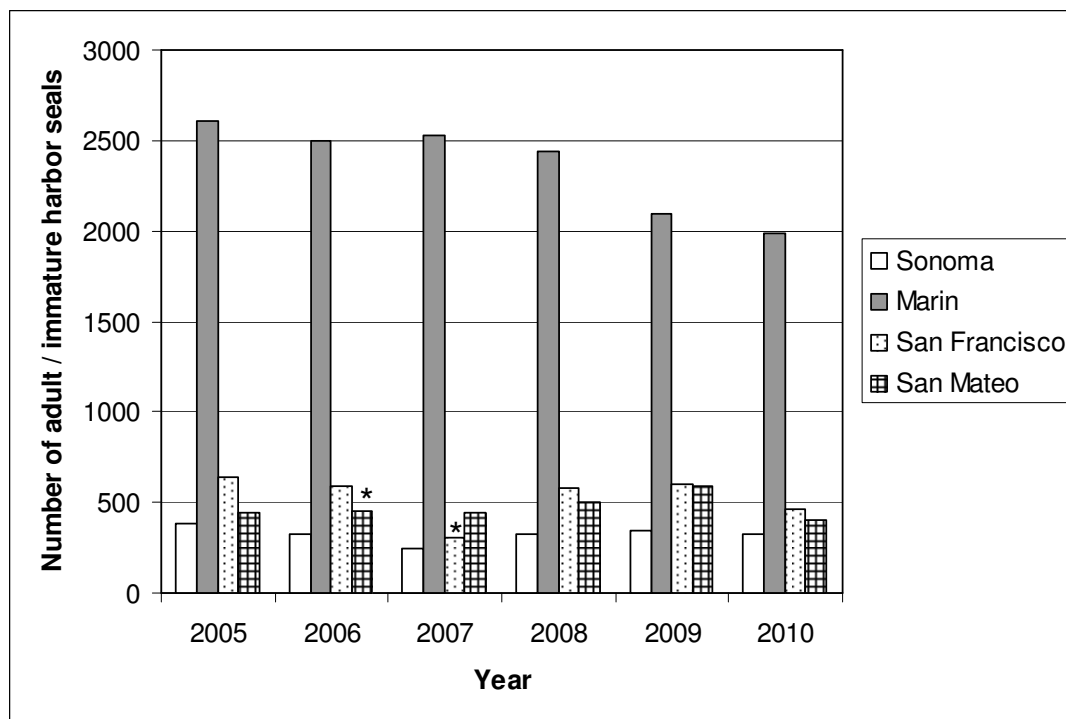


Figure 11. Maximum counts of harbor seal adults and immatures during the breeding season for the 2005-2010 regional surveys in central California. * Incomplete surveys conducted for San Mateo County in 2006 and San Francisco County in 2007.

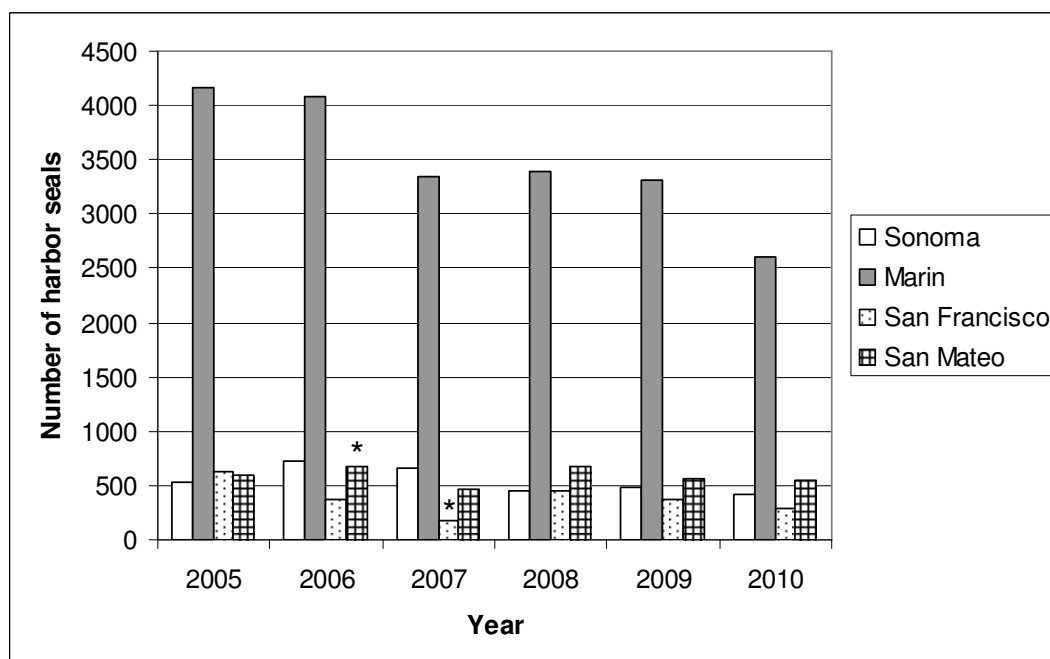


Figure 12. Maximum counts of all age classes of harbor seals during the molting season for the 2005-2010 regional surveys in central California. * Incomplete surveys conducted for San Mateo County in 2006 and San Francisco County in 2007.

Discussion

Pinnipeds are apex predators of the marine ecosystem, and numerous dynamic processes interacting together have the potential to affect their abundance, species composition and distribution. The collective knowledge gained about the recovery of pinnipeds since passage of the Marine Mammal Protection Act has been possible due to long-term monitoring programs that allow accurate interpretation of measured trends and responses to environmental and anthropogenic influences. Information gained at Point Reyes National Seashore and Golden Gate National Recreation Area contributes to predicting how recovered or disappearing populations will influence the ecosystem structure and productivity of this region. Studying trends and alterations in habitat also may provide insights into the potential or real effects of climate change on harbor seal distribution and abundance.

The SFAN has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Pinnipeds, particularly harbor seals, were selected for monitoring as an indicator of the marine ecosystem of the SFAN parks (Adams et al. 2006). Pinnipeds are one of the few species that inhabit both marine and terrestrial ecosystems; they forage and travel in the coastal waters of the parks but come onshore to rest, breed and molt. They reside in estuaries such as Tomales Bay, in rocky intertidal zones such as at Point Bonita, along pocket beaches such as at Tomales Point, and on islands such as Alcatraz. They also occur in special management zones such as wilderness areas and marine protected areas such as Point Reyes Headland and Drakes Estero. Harbor seals are sensitive to changes in the marine ecosystem and respond quickly to changes in prey abundance and distribution, and to human disturbance (Allen et al. 1985; Thompson and Miller 1990; Trillmich and Ono 1991; Thompson et al. 1998; Sydeman and Allen 1999).

From 2000-2010, Drakes Estero and Double Point annually produced the highest numbers of harbor seal pups. In 2010, these two sites combined produced 56% of the pups observed at Marin County sites. A similar trend is seen during the molting season, with these two sites comprising at least 50% of the seals recorded annually since 2000, except in 2009 when it dropped to 39%. In 2010, this percentage increased back up to 51%.

In 2010, the counts of adults/immatures and pups in the breeding season and seals counted during the molting season were the lowest numbers recorded between 2000 and 2010. One factor likely influencing this reduction was the moderate-to-strong 2009 El Niño-Southern Oscillation (ENSO) event (NOAA Climate Prediction Center 2010). A reduction in prey availability as a result of ENSO may have altered pup production and haulout patterns of adults and immatures as seen after previous strong ENSO events (Allen et al. 1989, Becker et al. 2009, Stewart et al. 1988). In 1998, during the strongest recorded ENSO event on record, harbor seal pup production was the lowest recorded for the study area between 1997 and 2001 (Allen et al. 2004). Sydeman and Allen (1999) reported an increase in harbor seals at offshore islands during an ENSO event, which may have been caused by seals moving away from nearshore feeding grounds in search of prey. However, in the current study, the adult and immature counts have been showing a decline in recent years prior to the 2009 ENSO, so there may be more factors affecting this decline. Further analysis on the long-term trends will explore the potential correlation between ENSO events and seal productivity and abundance.

Among Marin County locations, the time period when the maximum amount of pups was seen at each site was clustered around 3 weeks during the end of April and beginning of May. During the molting season, the peak at each site was more spread out with Drakes Estero being the anomaly and occurring at the end of July. The other locations peaked during the middle of June and the beginning of July. It is possible that this might have resulted in individual seals being counted more than once at different sites during the molting season. However, this would not change the overall result of this year having the lowest molt count in the past 10 years.

Throughout the study area from 2000-2010, the primary sites that experienced disturbances were Bolinas Lagoon, Drakes Estero, Point Bonita, and Tomales Bay. Disturbances at Point Bonita have decreased since the area was closed to visitors in mid-June 2007. In 2010, Tomales Bay had the highest number of disturbances recorded for the year, with the majority being caused by motorboats. Motorboats tend to disturb seals when they are too close in distance to the seals or when the boats are louder than normal background noise. The most common source category of disturbance for all Marin County locations combined in 2010 was human on foot, particularly hikers. This is consistent with previous years. The next most common disturbance categories were unknown and motorboats. The unknown source category is used when the surveyor observes seals displaying a disturbance response, such as head alert, flush towards water, or flush into water, but the source cannot be identified.

Collaborations

PORE staff assisted a graduate student from the Moss Landing Marine Lab under the guidance of Dr. James Harvey on a study to determine if harbor seals in San Francisco Bay are suffering from chronic selenium toxicity. This study is looking at seals in Tomales Bay, in addition to other locations in California. PORE staff was also involved with harbor seal monitoring training for the Stewards of the Coast and Redwoods Seal Watch program. Lastly, the central California coast regional surveys are collaborations with multiple government agencies, universities, and non-profit groups including the Golden Gate National Recreation Area, Fish and Wildlife Service, Moss Landing Marine Laboratories, University of California at Davis, Farallones National Marine Sanctuary Association, the Marine Mammal Center, and Stewards of the Coast and Redwoods Seal Watch program.

Season Highlights

- A maximum of 2,128 adults/immatures seals were counted onshore during the breeding season.
 - The greatest number of adults hauled out at Drakes Estero (610), followed by Double Point (380).
- A maximum of 811 pups were observed at Marin colonies.
 - Drakes Estero and Double Point accounted for 56% (453) of pups at Marin colonies.
 - Pup counts have been increasing at Point Bonita for the past few years.
- A maximum of 2,875 animals were counted during the molting season at Marin County haulout sites.

- Drakes Estero and Double Point comprised 51% (1,455) of the total seals counted during the molt season.
- The 2010 maximum counts during the breeding and molting seasons were the lowest recorded between 2000 and 2010. This could be due to the 2009 ENSO event.
- 114 disturbances were recorded during surveys.
 - The most frequent disturbance categories were humans on foot (31%), unknown (26%), and motorboat (24%).
- Regional surveys occurred 13 times throughout the breeding and molt seasons, which include Sonoma, Marin, San Francisco, and San Mateo counties. Seventeen volunteers participated in these surveys.
 - Marin County locations accounted for 62% of breeding season adults/immatures, 78% of pups, and 66% of seals during the molting season.
- 46 volunteers completed 214 surveys at Marin County locations between March 1st and July 31st 2009, contributing approximately 422 survey hours.

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